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The determination of the assailability of organic matter

INTRODUCTION

In biological research on litter and soil the question arises whether the organic matter that is present shows conformity as to absorbability or assailability by soil organisms.
One may reasonably suppose that recently fallen litter will contain a higher percentage of easily absorbable substances, such as proteins and carbohydrates, than does organic matter at greater depth in the soil. Carbohydrate - and protein-content can rather easily be determined quantitatively. The other organic substances besides lignin can be taken together as brown, hardly identifiable compounds. Their assailability cannot be estimated by any of the known standard methods.
However, I believe I have found a practicable method for indicating the assailability of various organic materials. The method is based on the degree to which a substance is oxidized by various concentrations of an oxidant. Plotting the percentage of the material that has not been oxidized against the concentration of the oxidant gives characteristic curves that make mutual comparison of the various materials possible.

METHODS

It appeared that various concentrations of the mixture potassium bichromate-sulfuric acid are very suitable for our purpose. The oxidation of the material can only be determined by measuring the liberated carbon dioxide. Even if nitrogen is allowed to pass through during the reaction, there is no point in titrating the remaining oxidant, because of the spontaneous reduction of the bichromate at the rather high reaction temperature. In order to prevent this disintegration as far as possible one would have to heat on a waterbath, but in that case the oxidation of the organic matter is far from complete.

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Comparison with dry combustion made it rather certain that all organic matter is quantitatively destroyed if boiled for 20 minutes in a mixture of 1 vol. part of 2 N $K_2Cr_2O_7$ and 2 vol. parts of H_2SO_4 - 96 %. The quantity of carbon dioxide liberated in the latter reaction has been taken as a standard for each substance that I examined. The carbon dioxide liberated at lower concentrations of the oxidant was expressed in percentages of the above standard.

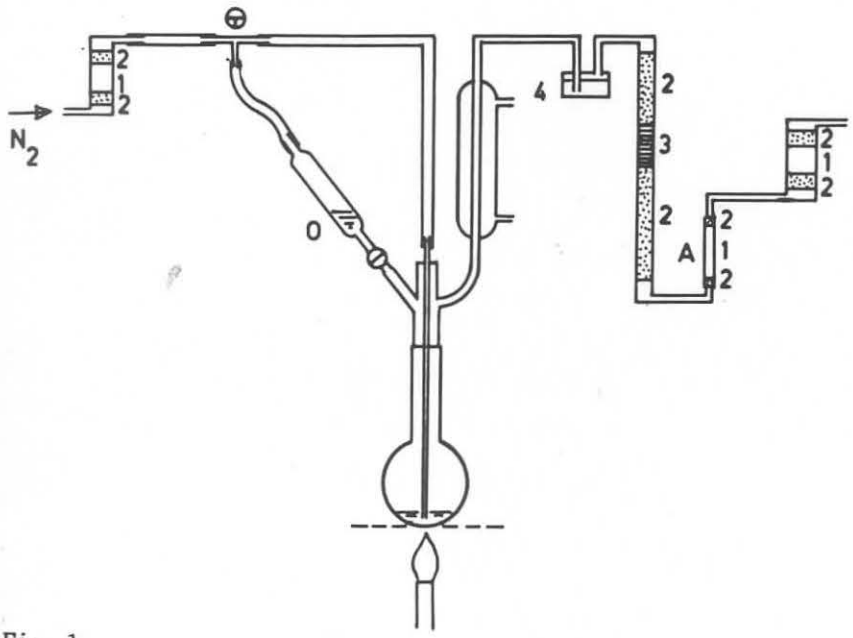

Fig. 1
Oxidation apparatus
A = absorbtion tube for carbon dioxide.
O = dosing-funnel by which the oxidant is added to the sample in the boiling flask.

The filling of the various vessels is indicated as follows:
1 = soda - asbestos,
2 = $CaCl_2$,
3 = MnO_2 (granulated),
4 = H_2SO_4 - 96 %.

The analyses were carried out in an apparatus shown in Fig. 1. The samples are put in the boiling flask. The sizes of the samples were preferably chosen so that 15 - 25 mg of carbon dioxide was collected in the weighable absorbtion-tube. Weighing should be done on semi-microscales.

Table 1: Concentrations of oxidant

$K_2Cr_2O_7$		+ H_2SO_4 (96%)
N	ml	ml
1/32	200	3
1/16	100	6
1/8	75	9
1/4	50	12
1/2	25	15
1	15	18
2	10	20

RESULTS AND DISCUSSION

In Fig. 2 the results are shown of the oxidation of soil samples from various depths, viz., of the uppermost layer of the mineral soil, and of the layer at a depth of 10 cm of the forest floor types acid mull and mor. Not the percentages oxidized, but the residues after oxidation are re-

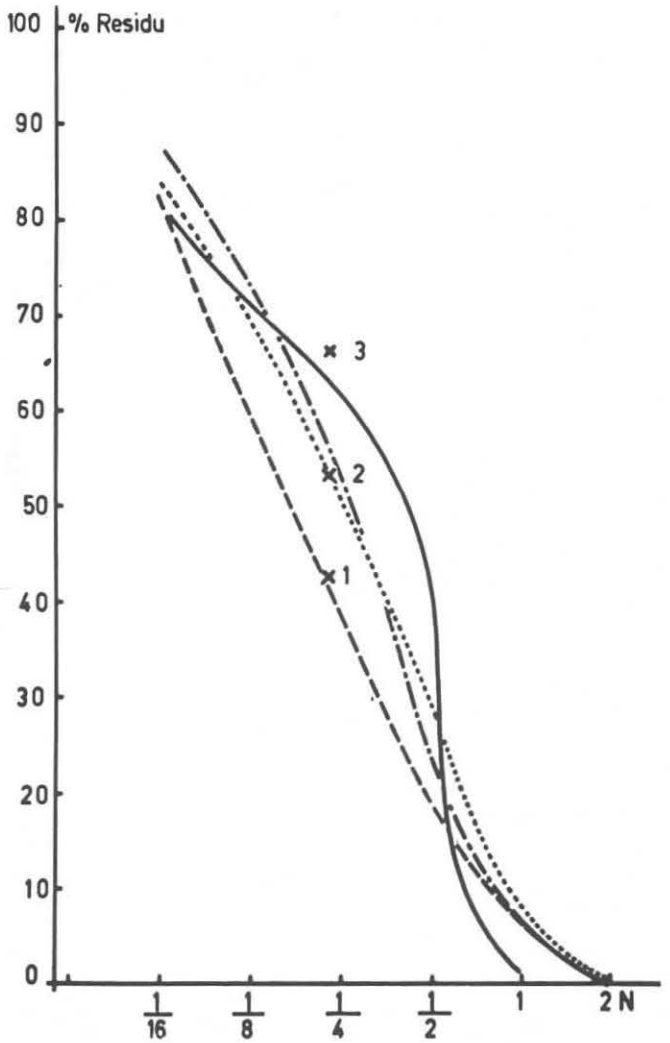

Fig. 2
Relation between concentration of oxidant and the residue after oxidation of the organic matter.
····· acid mull, depth of 0 cm
—·—·· acid mull, depth of 10 cm
– – – – mor, depth of 0 cm
——— mor depth of 10 cm.

Mark 1: oxidation residue of green leaves of oak, and also of alder
Mark 2: As above, but of lignin (Meadol)
Mark 3: As above, of 2-3 years old litter.

presented in these graphs. Three crosses (1, 2, 3) indicate the oxidation residues of green leaves of oak and alder (1), of the lignin preparation "Meadol" (2), and of the horizon between L- and F-litter of a mor under oak-forest (3) after treatment with 1/4 N oxidant. The two curves for the acid mull type show that there is little difference between the properties of the organic matter in the two layers that we examined. In my opinion this absence of any important difference is the result of activities of the soil fauna, which has intensively mixed organic matter with mineral soil over a depth greater than the distance between the two layers that we sampled. In the mor type the expected difference is found, as the organic matter in the upper layer appears to be more assailable than that in the lower layer. The visual observation that in mor, organic cover and mineral soil are not or little mixed by the soil fauna is born out by these analytical results.

The results of the oxidation of the three mentioned substances - green foliage, lignin, 2-3 years old litter - are as I expected. I draw attention to the fact that identical values were found for green leaves of oak and of alder.

From the shape of the Graph I venture to conclude that the use of 1/4 N potassium bichromate can provide a very satisfactory approximation of the relative assailability of organic matter.

In the analysis of a soil under very old oak forest the complete profile was methodically sampled and oxidized with 1/4, 1/2 and 2 N potassium bichromate. The results with 1/4 N are in my opinion the most satisfactory.

Table 2: Analysis of a profile in the Speulderbos
(oak on brown podsolic soil under mor)

Layer no.	Depth in profile cm	Residue of organic matter (%) after treatment with potassium bichromate			% C
		1/4 N	1/2 N	2 N	
1	F + H layer	37.0	22.5	0.0	35.56
2	0 - 6	41.5	14.5	0.0	7,76
3	6 - 18	62.2	47.5	0.0	2.66
4	18 - 38	52.8	26.4	0.0	1.36
5	38 - 58	66.7	24.5	0.0	.43
6	58 - 78	72.4	47.0	0.0	.19

The results of this analysis confirm that,in general,organic matter at greater depth in the soil is less assailable than in the top layers. However, irregularities may occur. This is shown by layer 3 which appears to have a lower assailability than both layers 4 and 5. Perhaps such abnormalities could have been prevented by removing visible remains of roots from the samples, though is is also possible that they are the result of visually hardly recognisable zoning of organic matter in the profile (analogous to phenomena in column-chromatography).

DISCUSSION

K. HAIDER: Ist es aufgrund der von Ihnen verwendeten Methode richtig zu sagen, daß die organische Bodensubstanz stabiler ist als Lignin? Welche Proben an organischer Bodensubstanz und welche Ligninproben wurden verwendet?

G. MINDERMAN: The bichromate method is used to indicate the differences in stability of various substances. The samples used are indicated in the text.

S.A. VISSER: It strikes me that the 1/4 N bichromate only oxidizes low molecular products such as amino acids and sugars, and leaves higher molecular substances substantially intact. I wonder whether the same effect could be achieved by estimating the cold or hot water extractable fractions.

My second comment concerns the fact that the method does not deal with biological specificity and selectivity. Microorganisms and plants select their substrates naturally and the uptake of nutrients is an active one, not just a diffusion process. That is, the action of the enzymes of microorganisms or plants may break down products which are not being attacked by the 1/4 N $K_2Cr_2O_7$.

G. MINDERMAN:The method was developed in order to differentiate various soil layers as to their assailability to microorganisms. We know that microbes will attack the organic matter in one layer more easily than in another. The bichromate oxidation method differentiates between the organic substance in these layers. The 1/4 N bichromate solution method is easy and gives a better insight of assailability than a water extract would. Moreover, making a good water extract is time consuming.

G. JAGNOW: Sind Parallelbestimmungen der biologischen Zersetzbarkeit vorgenommen worden und wenn ja, bestanden gute Korrelationen zu Ihrer chemischen Methode?

G. MINDERMAN: The microbiologists of the I.T.B.O.N. did find differences in the assailability of the organic matter in different layers. This led to the demand to evaluate this phenomenon in a chemical way. The results of both methods are in accordance with each other.